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# Role of modified atmospheric packaging in enhancing the shelf life and physical qualities of Pitaya fruit (*Hylocereus* spp.)

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**Abstract**
The present study was conducted at the Laboratory, Department of Horticulture, Assam Agricultural University, Jorhat which explains the influence of different modified atmospheric packaging films on the physical properties of dragon fruit under ambient and refrigerated conditions. The experiment was laid out with 6 treatments in a Completely Randomized Block Design with 4 replications. The treatments were $T_0$ (without packaging), $T_1$ (LDPE films), $T_2$ (HDPE films), $T_3$ (PVC films), $T_4$ (Polypropylene films), $T_5$ (Polyolefin films). In comparison to control, $T_5$ showed the highest shelf life (9.06 days) with the lowest PLW (3.64%), along with the lowest decay incidence (36.33%) of all treatments. In refrigerated condition, highest shelf life was shown by $T_5$ (27.38 days) with lowest PLW (4.71%) as compared to only 22.50 days with highest PLW (12.18%) in control whereas the decay incidence (%) was also less in $T_5$ (12.69%) compared to all other treatments. $T_5$ has been found to be the best treatment both for ambient and refrigerated conditions for enhancing shelf life. The present study concluded that $T_5$ was the best treatment for enhancing fruit weight and length under both ambient and refrigerated conditions.

**Keywords:** Dragon fruit, polypropylene, polyolefin, PVC films, shelf life

## 1. Introduction

Dragon fruit (*Hylocereus* spp.) is an epiphytic long-day plant belonging to the Cactaceae family. It is also known as 'Queen of the Night' due to its beautiful night-blooming flowers. Pitaya is divided into three types based on colour and presence of leafy skin: *Hylocereus undatus*: pink skin bearing white flesh; *Hylocereus polyrhizus*: pink skin bearing red flesh; *Hylocereus costaricensis*: pink skin bearing violet-red flesh and *Hylocereus* (Selenicerus) *megalanthus*: white flesh with yellowish skin. It is interesting to know that once the cultivation of dragon fruit plant is completed, it has the capacity to grow for about 20 years which can accommodate 800 plants in an area of one hectare. The fruit also has higher economic value and is gaining popularity among people due to its attractive color, shape and high nutritiousness (Harivaindaran *et al.*, 2008) [5]. The Department of Agriculture-Bureau of Agricultural Research (DA-BAR) has entitled dragon fruit as a 'money crop' because of its expensive rates in the local markets.

Pitaya is believed to be the leading fruit to be exported in Vietnam as it was first cultivated in Vietnam which helped in gaining wide attention among the riches. Pitaya is believed to be indigenous to Central America which reached out from Southern Mexico and Central America is the region where dragon fruit was first discovered years ago which reached all parts of the world including Australia and parts of Asia. According to the ICAR-National Institute of Abiotic Stress Management, Baramati, Maharashtra, dragon fruit cultivation is done in (3000-4000) hectares of land among various states of India. India in June, 2021 exported its first dragon fruit consignment to Dubai in the UAE from a farmer of Maharashtra, India.

As a seasonally produced fruit, dragon fruit has several drawbacks, including a short life even when stored at lower temperatures. Moreover, various post-harvest problems such as water loss, chilling injury, mechanical injury etc. also affect the quality of the fruits, marketability and overall post-harvest life of the product. In this context, Modified Atmospheric Packaging (MAP) is a known technique that enhances the storage life, and marketing ability of fruits and vegetables involving sealing of respiring food by the use of polymeric films with the aim of adjusting the oxygen, carbon-dioxide levels inside the packing films that have a wide impact on its metabolic activity, task of decay causing organisms and loss of moisture (Mir and Beaudry 2016) [8]. These benefits could be magnified further when MAP is integrated with refrigeration. Therefore, the present study aims on using different MAP films for extension of shelf life and quality of dragon fruit.

## 2. Materials and Methods

### 2.1 Plant Materials

Fruits were collected on the day of harvesting from the farm of a local farmer in the Morigaon district of Assam and taken to the laboratory. Fruits were cleaned and treated with Sodium hypochlorite (1%) for 5 minutes and dried in shade. The fruits were then subjected to different packaging treatments and kept under both storage conditions.

### 2.2 Treatments

There were six numbers of treatments with four replications**.** The design followed was Completely Randomized Block Design. The treatments followed were:

$T_1$: Fruits in LDPE films, $T_2$: Fruits in HDPE films, $T_3$: Fruits in PVC films, $T_4$: Fruits in polypropylene films, $T_5$: Fruits in polyolefin films, $T_0$: Control

A perforation of 0.76% is maintained in all the packaging films.

### 2.3 Shelf-life (days)

The shelf-life of the fruits was recorded in days by counting the number of days up to which the fruits remained in good condition.

### 2.4 Physiological loss in weight (PLW) (%)

The weight of the fruits of each treatment was recorded before packaging till storable days and the final loss in weight were recorded and the results were expressed in percentage using the following formula:

$$\text{PLW (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{FinalWeight}} \text{X100}$$

### 2.5 Decay incidence (%)

The decay-incidence of the fruits was recorded in % during the storage period.

$$\text{Decay loss (\%)} = \frac{\text{Weight of decayed fruit}}{\text{Weight of fruit (initial)}} \text{X100}$$

### 2.6 Fruit weight (g)

Fruit weight was taken before packaging and at three days interval after packaging in room temperature and at 7 days interval in refrigerated condition.

### 2.7 Fruit length (cm)

Vernier-calliper was used for measuring length of the fruits which was expressed in centimeter.

## 3. Results

### a. Shelf life (days) under ambient condition

The observations related to influence of packaging films on shelf life (days) under ambient condition are tabulated in Table 1. The tabulated data mentioned below shows that among all the treatments, the highest shelf life was obtained in $T_5$ (9.06 days) and lowest in $T_0$ (7.63 days). The differences were found to be significant. The trends of influence of packaging films on shelf life (days) in descending order is given below: $T_5>T_2>T_1>T_3> T_4>T_0$.

**Table 1:** Shelf life (days) under ambient condition

| Treatments | Shelf life (days)* |
|---|---|
| $T_0$: Control | 7.63 |
| $T_1$: LDPE | 8.88 |
| $T_2$: HDPE | 9.00 |
| $T_3$: PVC | 8.38 |
| $T_4$: Polypropylene | 8.25 |
| $T_5$: Polyolefin | 9.06 |
| SE. d (±) | 0.31 |
| C.D @ 5% | 0.65 |

*(Mean of four replications)

### b. Shelf life (days) under refrigerated condition

The observations related to influence of packaging films on shelf life (days) under refrigerated condition are tabulated in Table 2. The tabulated data mentioned below shows that among all the treatments, the highest shelf life was obtained in $T_5$ (27.38 days) and lowest in $T_0$ (22.50 days). The differences were found to be significant. The trends of influence of packaging films on shelf life (days) in descending order is given below: $T_5>T_2>T_1>T_3>T_4>T_0$

**Table 2:** Shelf life (days) under refrigerated condition

| Treatments | Shelf life (days)* |
|---|---|
| $T_0$: Control | 22.50 |
| $T_1$: LDPE | 25.63 |
| $T_2$: HDPE | 26.63 |
| $T_3$: PVC | 25.38 |
| $T_4$: Polypropylene | 24.38 |
| $T_5$: Polyolefin | 27.38 |
| SE. d (±) | 0.33 |
| C.D @ 5% | 0.70 |

*(Mean of four replications)

### c. Physiological loss in weight (%) under ambient condition

The observations related to the influence of packaging films on the physiological loss in weight (%) under ambient conditions are tabulated in Table 3. The tabulated data mentioned below shows that among all the treatments, the highest physiological loss in weight (%) was found in $T_0$ (5.29%) and the lowest was found in $T_5$ (3.64%). The differences were found to be non-significant. The trend of influence of packaging films on physiological loss in weight (%) in decreasing order is given below: $T_0>T_4>T_1>T_3>T_2>T_5$

**Table 3:** Physiological loss in weight (%) under ambient condition

| Treatments | PLW (%) * |
|---|---|
| $T_0$: Control | 5.29 |
| $T_1$: LDPE | 4.41 |
| $T_2$: HDPE | 4.14 |
| $T_3$: PVC | 4.17 |
| $T_4$: Polypropylene | 4.44 |
| $T_5$: Polyolefin | 3.64 |
| SE. d (±) | 0.82 |
| C.D @ 5% | N/S |

*(Mean of four replications), (N/S. Non-Significant)

### d. Physiological loss in weight (%) under refrigerated condition

The observations related to influence of packaging films on the PLW (%) under refrigerated condition are tabulated in Table 4. The tabulated data mentioned below shows that among all the treatments, the highest physiological loss in weight (%) was found in $T_0$ (12.18%) and lowest was found in $T_5$ (4.71%). The differences were found to be significant. The trend of influence of packaging films on physiological loss in weight (%) in decreasing order is given below: $T_0>T_1>T_4>T_3>T_2>T_5$

**Table 4:** Physiological Loss in Weight (%) under refrigerated condition

| Treatments | PLW (%)* |
|---|---|
| $T_0$: Control | 12.18 |
| $T_1$: LDPE | 6.69 |
| $T_2$: HDPE | 5.25 |
| $T_3$: PVC | 5.33 |
| $T_4$: Polypropylene | 6.10 |
| $T_5$: Polyolefin | 4.71 |
| SE. d (±) | 1.19 |
| C.D @ 5% | 2.51 |

*(Mean of four replications)

**e. Decay incidence (%) under ambient condition**

The observations related to the influence of packaging films on Decay incidence (%) under ambient conditions are tabulated in Table 5. The tabulated data mentioned below shows that among all the treatments, the highest decay incidence (%) was obtained in $T_0$ (96.66%) and lowest in $T_5$ (36.33%). The differences were found to be significant. The trend of influence of packaging films on decay incidence (%) in decreasing order is given below: $T_0>T_1>T_3>T_4>T_2>T_5$

**Table 5:** Decay Incidence (%) under ambient condition

| Treatments | Decay incidence (%)* |
|---|---|
| $T_0$: Control | 96.66 |
| $T_1$: LDPE | 68.33 |
| $T_2$: HDPE | 38.66 |
| $T_3$: PVC | 66.66 |
| $T_4$: Polypropylene | 56.66 |
| $T_5$: Polyolefin | 36.33 |
| SE. d (±) | 1.96 |
| C.D.@ 5% | 4.03 |

*(Mean of four replications)

**f. Decay incidence (%) under refrigerated condition**

The observations related to influence of packaging films on Decay incidence (%) under refrigerated condition are tabulated in table 6. The tabulated data mentioned below shows that among all the treatments, the highest decay incidence (%) was obtained in $T_0$ (23.88%) and lowest in $T_5$ (12.69%). The differences were found to be significant. The trend of influence of packaging films on decay incidence (%) in decreasing order is given below:
$T_0>T_2>T_1>T_4>T_3>T_5$

**Table 6:** Decay Incidence (%) under refrigerated condition

| Treatments | Decay incidence (%) * |
|---|---|
| $T_0$: Control | 23.88 |
| $T_1$: LDPE | 19.00 |
| $T_2$: HDPE | 19.31 |
| $T_3$: PVC | 15.13 |
| $T_4$: Polypropylene | 17.34 |
| $T_5$: Polyolefin | 12.69 |
| SE. d (±) | 0.63 |
| C.D @ 5% | 1.34 |

*(Mean of four replications)

**g. Fruit weight (g) under ambient condition**

The observations related to influence of packaging films on fruit weight (g) under ambient conditions are tabulated in table 7. Among all the treatments studied, on 3rd day of packaging, the highest fruit weight (g) was found in $T_5$ (326.50 g, 0.87% loss) and lowest fruit weight (g) was found in $T_0$ (272.25 g, 1.98% loss). On 6th day of packaging the highest fruit weight (g) was found in $T_5$ (322.50 g, 2.08% loss) and lowest fruit weight (g) was found in $T_0$ (268.50 g, 3.33% loss). On 9th day of packaging, the highest fruit weight (g) was found in $T_5$ (317.38 g, 3.64% loss) and lowest fruit weight (g) was found in $T_0$ (263.05 g, 5.29% loss). The differences were found to be significant on 3rd, 6th and 9th day of packaging. It was observed that there was a decrease in fruit weight (g) in all the treatments on 9th day of packaging as compared to 3rd and 6th day of packaging.

**Table 7:** Fruit weight (g) under ambient condition

| s | Initial | Day 3* | Day 6* | Day 9* |
|---|---|---|---|---|
| $T_0$: Control | 277.75 | 272.25 (1.98%) | 268.50 (3.33%) | 263.05 (5.29%) |
| $T_1$: LDPE | 286.12 | 282.00 (1.44%) | 277.50 (3.01%) | 273.50 (4.41%) |
| $T_2$: HDPE | 310.88 | 306.00 (1.57%) | 302.00 (2.86%) | 298.00 (4.14%) |
| $T_3$: PVC | 290.88 | 286.88 (1.38%) | 283.63 (2.49%) | 278.75 (4.17%) |
| $T_4$: Polypropylene | 298.25 | 295.00 (1.09%) | 290.88 (2.47%) | 285.00 (4.44%) |
| $T_5$: Polyolefin | 329.38 | 326.50 (0.87%) | 322.50 (2.08%) | 317.38 (3.64%) |
| SE. d (±) | 7.88 | 7.83 | 7.85 | 7.69 |
| C. D @ 5% | 16.60 | 16.58 | 16.61 | 16.29 |

* (Mean of four replications)

**h. Fruit weight (g) under refrigerated condition**

The observations related to influence of packaging films on fruit weight (g) under refrigerated condition are tabulated in Table 8. Among all the treatments studied, on 7th day of packaging, the highest fruit weight (g) was found in $T_5$ (346.00 g, 2.74% loss) and lowest fruit weight (g) was found in $T_0$ (205.75 g, 5.40% loss). On 14th day of packaging, the highest fruit weight (g) was found in $T_5$ (341.25 g, 4.08% loss) and lowest fruit weight (g) was found in $T_0$ (196.50 g, 9.66% loss). On 21st day of packaging, the highest fruit weight (g) was found in $T_5$ (339.00 g, 4.71% loss) and lowest fruit weight (g) was found in $T_0$ (191.00 g, 12.18% loss). The differences were found to be significant on 7th, 14th and 21st day of packaging. It was observed that there was a decrease in fruit weight (g) in all the treatments on 21st day of packaging as compared to 7th and 14th day of packaging.

**Table 8:** Fruit weight (g) under refrigerated condition

| Treatments | Initial | Day 7* | Day 14* | Day 21* |
|---|---|---|---|---|
| $T_0$: Control | 217.50 | 205.75 (5.40%) | 196.50 (9.66%) | 191.00(12.18%) |
| $T_1$: LDPE | 246.75 | 237.25 (3.85%) | 232.75 (5.67%) | 230.25 (6.69%) |
| $T_2$: HDPE | 304.75 | 299.25 (1.80%) | 294.25 (3.45%) | 288.75 (5.25%) |
| $T_3$: PVC | 269.35 | 262.00 (2.73%) | 258.25 (4.12%) | 255.00 (5.33%) |
| $T_4$: Polypropylene | 245.75 | 240.75 (2.03%) | 236.75 (3.66%) | 230.75 (6.10%) |
| $T_5$: Polyolefin | 355.75 | 346.00 (2.74%) | 341.25 (4.08%) | 339.00 (4.71%) |
| SE. d (±) | 21.25 | 21.04 | 20.26 | 20.76 |
| C.D @ 5% | 44.58 | 44.51 | 42.89 | 43.96 |

* (Mean of four replications)

### i. Fruit length (cm) under ambient condition

The observations related to the influence of packaging films on fruit length (cm) under ambient conditions are tabulated in Table 9. Among all the treatments studied, on 3rd day of packaging, the highest fruit length (cm) was found in $T_5$ (10.19 cm, 0.59% loss) and the lowest fruit length (cm) was found in $T_1$ (7.91 cm, 0.50% loss). On 6th day of packaging, the highest fruit length (cm) was found in $T_5$ (10.13 cm, 1.17% loss) and the lowest fruit length (cm) was found in $T_1$ (7.83 cm, 1.51% loss). On 9th day of packaging, the highest fruit length (cm) was found in $T_5$ (10.10 cm, 1.46% loss) and lowest fruit length (cm) was found in $T_1$ (7.78 cm, 2.14% loss). The differences were found to be significant on 3rd, 6th and 9th day of packaging. Fruit length (cm) was found to decrease more on 9th day than on 3rd and 6th day of packaging.

**Table 9:** Fruit length (cm) under ambient Condition

| Treatments | Initial | Day 3* | Day 6* | Day 9* |
|---|---|---|---|---|
| $T_0$: Control | 8.55 | 8.40 (1.75%) | 8.31 (2.81%) | 8.20 (4.09%) |
| $T_1$: LDPE | 7.95 | 7.91 (0.50%) | 7.83 (1.51%) | 7.78 (2.14%) |
| $T_2$: HDPE | 8.95 | 8.91 (0.45%) | 8.79 (1.79%) | 8.75 (2.23%) |
| $T_3$: PVC | 8.25 | 8.10 (1.82%) | 8.01 (2.91%) | 7.97 (3.39%) |
| $T_4$: Polypropylene | 8.66 | 8.53 (1.50%) | 8.47 (2.19%) | 8.43 (2.66%) |
| $T_5$: Polyolefin | 10.25 | 10.19 (0.59%) | 10.13 (1.17%) | 10.10 (1.46%) |
| SE. d (±) | 0.06 | 0.05 | 0.05 | 0.06 |
| C.D @ 5% | 0.12 | 0.11 | 0.10 | 0.11 |

* (Mean of four replications)

### j. Fruit length (cm) under refrigerated condition

The observations related to the influence of packaging films on fruit length (cm) under refrigerated conditions are tabulated in Table 10. Among all the treatments studied, on 7th day of packaging, the highest fruit length (cm) was found in $T_5$ (10.10 cm, 0.49% loss) and lowest fruit length (cm) was found in $T_1$ (7.28cm, 0.55% loss). On 14th day of packaging, the highest fruit length (cm) was found in $T_5$ (10.00 cm, 1.47% loss) and lowest fruit length (cm) was found in $T_1$ (7.05 cm, 3.69% loss). On 21st day of packaging, the highest fruit length (cm) was found in $T_5$ (9.88 cm, 2.66% loss) and lowest fruit length (cm) was found in $T_1$ (6.78 cm, 7.38% loss). The differences were found to be significant on 7th, 14th and 21st day of packaging. Fruit length (cm) was found to decrease more on 21st day than on 7th and 14th day of packaging.

**Table 10:** Fruit length (cm) under refrigerated condition

| Treatments | Initial | Day 7* | Day 14* | Day 21* |
|---|---|---|---|---|
| $T_0$: Control | 7.55 | 7.35 (2.65%) | 7.15 (5.29%) | 6.88 (8.87%) |
| $T_1$: LDPE | 7.32 | 7.28 (0.55%) | 7.05 (3.69%) | 6.78 (7.38%) |
| $T_2$: HDPE | 9.28 | 9.23 (0.54%) | 9.14 (1.50%) | 9.00 (3.02%) |
| $T_3$: PVC | 9.10 | 9.02 (0.88%) | 8.70 (4.39%) | 8.50 (6.59%) |
| $T_4$: Polypropylene | 8.25 | 8.15 (1.21%) | 8.10 (1.82%) | 8.00 (3.03%) |
| $T_5$: Polyolefin | 10.15 | 10.10 (0.49%) | 10.00 (1.47%) | 9.88 (2.66%) |
| SE.d (±) | 0.11 | 0.12 | 0.15 | 0.16 |
| C.D @ 5% | 0.27 | 0.26 | 0.32 | 0.36 |

* (Mean of four replications)

**Plate 1:** Different Treatments at ambient condition

**Plate 2:** Different Treatments at refrigerated condition

## 4. Discussion

The present study explains the influence of different modified atmospheric packaging films on the shelf life as well as on physical properties of dragon fruit under ambient and refrigerated condition. Rational arguments to bring about clear understanding of reasons based on the results are discussed below under respective headings.

### 4.1 Shelf life

Shelf life showed significant variations in response to various treatments under ambient condition (Table 1). The highest shelf life was found in $T_5$ (9.06 days) and lowest shelf life was found in $T_0$ (7.63 days). The highest shelf life may be due to positive influence of the packaging film or may be due to hydrophobic behavior of the packaging film as no treatment led to a shelf life of 7.63 days only in control because in open condition at ambient temperature, more oxygen concentration leads to rapid rate of respiration. Similar results were obtained by Zee *et al.* (2004) [14] in which the fruits stored at room temperature had a shelf life of less than 10 days. Shelf life showed significant variation in response to various treatments under refrigerated condition (Table 2). The highest shelf life was found in $T_5$ (27.38 days) and lowest shelf life was found in $T_0$ (22.50 days). The increase in shelf life in $T_5$ may be due to sensitiveness of the packaging film towards moisture. Similar results were obtained by Zee *et al*. (2004) [14] in which the fruits stored at 4.5 ºC had a shelf life of (25-30) days. Similarly, Samir *et al*. (2019) [15] also reported that quality of the vegetable 'dill' can be maintained by extending the cold storage period.

### 4.2 Physiological loss in weight

Physiological loss in weight showed no significant variations in response to various treatments under ambient condition (Table 3). Highest physiological loss in weight was observed in $T_0$ (5.29%) and lowest was observed in $T_5$ (3.64%). The higher rate of loss in control may be due to higher loss of moisture from the fruits and increase in respiration in comparison to wrapped fruits. Lowest PLW in $T_5$ may be due to positive role of packaging film which creates micro-atmosphere around the fruits and thus helps in preventing dehydration (Gonzalez *et al.*, 1997). Significant variations were shown in response to various treatments under refrigerated condition (Table 4). The highest rate of loss was observed in $T_0$ (12.18%) and lowest PLW was observed in $T_5$ (4.71%). The lowest PLW in $T_5$ may be due to the role of packaging film acting as a mechanical barrier to the movement of water vapor which helps in maintaining saturated micro-atmosphere around the fruits and thus reduce loss in weight (Suparlan and Itoh, 2003) [12]. Similar trend of results were obtained by Schotsmans *et al*. (2008) [18] in passion fruit.

### 4.3 Decay Incidence (%)

Decay incidence showed significant variations in response to various treatments under ambient condition (Table 5). $T_0$ showed highest percentage of decay incidence (96.66%) and lowest was observed in $T_5$ (36.33%). The higher incidence of decay in control may be due to higher respiration rate or increase in microorganisms attack in open condition. The lower incidence of decay in $T_5$ may be due the packaging film's ability in retaining a higher level of $CO_2$ inside the package which might exhibit a fungistatic effect and reduced respiration rate. Respiration rate gets reduced with lower rate of oxygen and higher concentration of carbon dioxide inside the packaging for which the incidence of decay is minimum (Li and Kader, 1989). Significant variations were shown in response to various treatments under refrigerated condition (Table 6). The highest decay incidence was observed in $T_0$ (23.88%) and lowest decay incidence was observed in $T_5$ (12.69%). The lowest incidence of decay in $T_5$ may be due to positive effect of the packaging film in maintaining lower relative humidity thus reducing the respiration rate and microorganism's activity in the fruits. Punitha *et al.* (2009) [10] reported that low temperatures delay senescence and fruit softening during storage.

### 4.4 Fruit weight (g)

Fruit weight showed significant variations in response to various treatments under ambient condition (Table 7) Fruit weight was found to decrease gradually in all the treatments during the storage period which may be due to loss of moisture from the fruits, faster metabolism or increase in cell wall degradation. Lower weight loss in $T_5$ may be due to the effect of packaging film in slowing down the rate of respiration thus reducing loss of moisture. Similar results were obtained by Topuz *et al*. (2005) [13] in orange, Ertekin *et al.* (2006) [3] in plum, Kheiralipour *et al*. (2008) [6] in apple and Mohd (2010) [9] in dragon fruit. Significant variations were shown in response to various treatments under refrigerated condition (Table 8). Fruit weight was found to decrease gradually in all the treatments during the storage period which may be due to loss of moisture from the fruits. Lower loss in wight in $T_5$ may be due to the effect of packaging film in reducing the respiration and transpiration rate at lower temperature. Similar results were obtained by Crisosto *et al.* (2001) [2] and (Ben-Yehoshua and Rodov, 2003) [1].

### 4.5 Fruit length (cm)

Fruit length showed significant variations in response to various treatments under ambient conditions (Table 9). Fruit length was found to decrease in all the treatments during the storage period which may be due to loss of moisture from the fruits and reduction in size of the fruits. Significant variations were also shown in response to various treatments under refrigerated conditions (Table 10). Fruit length was found to decrease in all the treatments during the storage period which may be due to loss of moisture from the fruits and reduction in fruit size. A similar trend of results has been obtained by Topuz *et al.* (2015) [13] in orange, Ertekin *et al.* (2006) [3] in plum, Kheiralipour *et al*. (2008) [6] in apple and Mohd (2010) [9] in dragon fruit.

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